Appendix III.

Lower Clear Creek Monitoring Plan and Tables

Contents:

ECOLOGICAL MONITORING PLAN
FOR
LOWER CLEAR CREEK
FLOODWAY REHABILITATION PROJECT

***Presented To*:**

CALFED Bay Delta Program
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INTRODUCTION

On behalf of the Lower Clear Creek Restoration Team (Restoration Team) the Western Shasta Resource Conservation District (WSRCD) applied for a grant to CALFED in May of 1998 to begin restoration of the lower Clear Creek stream channel and floodplain. The Restoration Team is comprised of representatives from various federal, state and local resource agencies as follows:

Bureau of Reclamation
U.S. Fish and Wildlife Service
National Marine Fisheries Service
Bureau of Land Management
National Park Service
Clear Creek CRMP Group
Natural Resources Conservation Service
California Department of Fish and Game
California Department of Water Resources
Western Shasta Resource Conservation District
Central Valley Water Users Association
Central Valley Hydro-power users
Horsetown Clear Creek Preserve

The grant application proposed to restore a severely degraded reach of lower Clear Creek impacted by extensive gold and gravel mining activities. The project was logically divided into four phases and includes restoration of floodplains and upland habitats upstream of the project where borrow activities are planned. Phase 1 of the project was completed in 1998 with funds provided through the Central Valley Project Improvement Act (CVPIA) and included construction of a natural bar (plug) to reduce stranding of juvenile salmon and improve passage conditions for adult salmon migrating upstream. Phase 2 will initiate restoration of floodplains and further reduce stranding of juvenile salmonids by filling aggregate extraction pits within the stream channel and floodplain. Phase 3 will focus on rehabilitating the active stream channel, improving floodplain connectivity, and revegetation of natural riparian communities. Phase 4 will restore flow into a section of historic stream channel diverted by aggregate extraction. The grant proposal submitted to CALFED requested funds to implement Phases 2 through 4 however, only Phase 2 of the project was funded during the 1998 solicitation process. A second CALFED grant application was submitted in the Spring of 1999 for funding of Phases 3 and 4. This monitoring plan encompasses monitoring activities for all phases under the assumption that all four phases of the project will be implemented.

CALFED MONITORING PLAN REQUIREMENTS

CALFED requires successful grant applicants to complete ecological and biological monitoring plans where appropriate. For the *Lower Clear Creek Floodway Rehabilitation Project* a monitoring plan must be submitted, reviewed and approved by CALFED. The CALFED Proposal Solicitation Package under which Phase 2 of the *Lower Clear Creek Floodway Rehabilitation Project* was selected states that at a minimum the monitoring plan shall include:

- objectives of the monitoring;
- questions to be addressed through monitoring (hypothesis);
- personnel conducting the monitoring and their related experience;
- duration of monitoring;
- constituents to be monitored;
- sampling methods;
- locations and frequencies of measurement; and
- reporting formats.

The monitoring plan must also incorporate a Quality Assurance Project Plan (QAPP) and annual monitoring reports must be submitted to CALFED presenting findings and a determination as to whether monitoring objectives have been achieved. This monitoring plan was prepared on behalf of the WSRCD by the U.S. Bureau of Reclamation (BR) to comply with CALFED monitoring requirements.

PROJECT MONITORING OBJECTIVES

The primary objective of the *Lower Clear Creek Floodway Rehabilitation Project* is to initiate rehabilitation by restoring a natural channel and floodplain morphology, and native riparian vegetation. Restoration of a natural channel and floodplain in combination with appropriate flow releases will initiate and sustain natural sediment transport processes and channel migration; restore aquatic, wetland, and riparian habitats; improve floodplain connectivity and riparian regenerative processes; and ecological function to the riverine ecosystem. Successful achievement of this objective is anticipated to provide several ecological benefits within the lower Clear Creek Floodway. These ecological benefits are expected to:

- Reduce juvenile stranding mortality and improve adult salmonid passage conditions;
- Increase salmonid spawning habitat;
- Improve geomorphic processes that create and maintain habitat for salmonids and other aquatic species;
- Improve channel-to-floodplain connectivity, improving nutrient and fine sediment cycling throughout the floodway;

- Increase native riparian vegetation, particularly canopy species (cottonwood) important for avian habitat;
- Reduce exotic vegetation through active removal and replacement with native species, and;
- Improve wetland values.

To evaluate project success relative to the ecological benefits stated above specific monitoring objectives were developed and logically divided into three categories for evaluation (Table 1). The three categories developed include fishery resources, geomorphology, and riparian communities.

FISHERIES MONITORING OBJECTIVES

Under current conditions fishery habitat within the project reach has been degraded by removal of alluvial material from the channel and floodplain. Clay and bedrock surfaces have become exposed within the channel reducing the quality and quantity of spawning habitat. The occurrence of shallow braided channels may hinder adult salmon migration upstream during low flow periods that persist during the fall. Several remnant aggregate excavation pits and lowered floodplain surfaces strand fry and juvenile salmonids during periods of fluctuating flow, which are common during the late winter and spring rearing periods. Creation of a restored naturally functioning stream channel and floodplain are anticipated to improve salmon spawning and rearing habitat, reduce the juvenile salmonid stranding, and improve adult passage conditions through the reach.

To evaluate project success in restoring degraded fishery habitat the Restoration Team developed three primary objectives to monitor and evaluate. The objectives were developed to answer specific questions relative to salmonid habitat and survival. The three specific monitoring objectives are:

F1. Improve salmonid rearing and spawning habitat within the project reach.

F2. Reduce juvenile salmonid stranding mortality.

F3. Improve adult passage conditions through the project reach upstream.

Table 1. Ecological objectives, hypotheses, and study parameters for Lower Clear Creek Floodplain Rehabilitation Project.

I) Biological/Ecological Project Objectives For Fishery Resources.

OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
Objective F1: Improve salmonid rearing and spawning habitat within the project reach. Hypothesis F1. Implementation of channel restoration project will increase the quality and quantity of salmonid (chinook salmon and steelhead trout) habitat within the project study area.	Map meso-habitats and conduct habitat transect measurements for meso-habitats throughout the project study area. Monitor meso-habitat use by rearing juvenile and spawning adult salmonids using direct observation methods, bank observations and snorkel divers, within project site.	Use established IFIM-PHABSIM methodologies to describe habitat availabilities for rearing and spawning salmonids prior to and after habitat restoration. Compare total habitat area and weighted usable area (WUA) for each life stage before and after channel restoration. Compare habitat use in meso-habitats prior to and after habitat restoration.	USFWS Spawning use has been monitored over a three year period and some baseline data is available. High Priority.	CVPIA 3406(b)(12).
ObjectiveF2: Reduce juvenile salmonid stranding mortalities Hypothesis F2. Implementation of channel restoration project will decrease stranding induced mortality of adult and juvenile salmonids within the project reach.	Survey stream channel and floodplain locations using direct observation, electrofishing and seining techniques throughout project study area immediately following flood events to determine extent of juvenile stranding.	Compare stranding survey data before and after channel and floodplain restoration efforts are complete.	USFWS Stranding of juvenile salmonids is recognized as a serious problem by resource agencies. High Priority.	CVPIA 3406(b)(12)
ObjectiveF3: Improve adult passage conditions through the project reach upstream. Hypothesis F3. Implementation of channel restoration project will improve passage conditions for adult salmon and steelhead trout through the project reach upstream.	Visually assess adult salmon passage during upstream migration through the project over critical riffles to determine if current conditions inhibit adult passage upstream. If passage problems occur, map problem areas and establish transects across critical riffles to quantify hydraulic parameters, water depth and velocity, during the migration period.	If passage problems are identified, describe existing passage conditions and compare hydraulic conditions over critical riffles prior to and after habitat restoration.	USFWS Implementation of Phase 1 during 1998 corrected the most serious adult passage concern. Other areas within the project site are not considered to be significant passage problems. Moderate Priority.	CVPIA 3406(b)(12)

Table 1. Ecological objectives, hypotheses, and study parameters for Lower Clear Creek Floodplain Rehabilitation Project. Continued.

II) Biological/Ecological Project Objectives for Geomorphology.

Objective/Hypothesis	Monitoring Parameter (s) and Data Collection Approach	Data Evaluation Approach	Monitoring Agent, Comments, Study Priority	Funding
Objective G1: Recreate a properly sized alluvial channel morphology. Hypothesis G1: Coarse sediment will be mobilized by design bankfull flow (the bed moves)	The monitoring parameter will be percentage of tracer rocks mobilized for different alluvial features (point bars, riffles, pool tails, etc). Tracer rocks will be installed on at least two point bars and two riffles within the project reach, and monitored for mobilization and distance after each discrete high flow event sufficient to cause mobilization.	Tracer rocks will be evaluated by: 1) whether they moved, and 2) how far they moved. The former will allow us to evaluate whether the bed is mobilized by design bankfull discharge, and the latter will provide information on particle travel distance as a function of flow and duration of flow.	WSRCD Will allow designers to improve bankfull channel design for later projects. Moderate priority	Currently CVPIA, CALFED is anticipated future source.
Objective G2: Recreate a properly sized alluvial channel morphology. Hypothesis G2: The bankfull channel will migrate or avulse during flows approaching bankfull discharge and larger (the channel migrates)	The monitoring parameter will be bankfull channel location within the valley-wide cross section, and planform location over time. Cross sections will be installed throughout two alternate bar sequences (targeting meander bends). Post-construction aerial photographs will be rubber-sheeted and channel location digitized and overlain on previous channel locations.	Migration or avulsion of the bankfull channel will be evaluated by comparing channel response (feet moved, rate of movement) with the magnitude and duration of flow that caused the channel to migrate.	WSRCD Much of this will be collateral information gathered with other geomorphic monitoring activities. Moderate priority	Currently CVPIA, CALFED is anticipated future source
Objective G3: Recreate a properly sized alluvial channel morphology. Hypothesis G3: Flows exceeding design bankfull discharge will begin inundating constructed floodplains.	The monitoring parameter will be water surface elevation within the bankfull channel, and flow discharge for that water surface elevation. At one site assessable during high flows at the project site and borrow site water surface elevations will be predicted during the design phases, and elevations will be measured during high flow events after construction.	Measured water surface elevations will be compared to constructed floodplain elevations, and hydraulic parameters will also be collected to refine hydraulic model.	WSRCD Will allow designers to improve bankfull channel design for later projects. Moderate priority	Anticipated CALFED Grant

Table 1. Ecological objectives, hypotheses, and study parameters for Lower Clear Creek Floodplain Rehabilitation Project. Continued.

II) Biological/Ecological Project Objectives for Geomorphology.				
OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
Objective G4: Recreate a properly sized alluvial channel morphology. Hypothesis G4: Flows exceeding design bankfull discharge will begin depositing fine sediments (sand and silt) on constructed floodplains	The monitoring parameter will be water surface elevation within the bankfull channel, flow discharge for that water surface elevation, and fine sediment deposition on floodplains At one site accessible during high flows at the Borrow Site and Project Site water surface elevations will be measured during high flow events after construction, and a depth flow threshold for fine sediment deposition will be sought.	Water surface elevations will be compared to constructed floodplain elevations (to get water depths); then, fine sediment deposition will be measured by cross sections and scour nails, and sediment composition will be documented by bulk substrate sampling. The source of the high flow (tributary derived vs dam spill) will be considered and when feasible (safe), depth integrated suspended sediment samples will be collected and analyzed for particle size distribution.	WSRCD Fine sediment deposition on floodplains is critical for natural riparian regeneration. There may also be significant depositional differences between tributary generated flood events and dam generated flood events. Moderate priority	Anticipated CALFED Grant
Objective G5: Raise channel above bedrock hardpan, increasing alluvial storage within the bankfull channel. Hypothesis G5: Subsequent high flows and reductions in sediment supply upstream available upstream of the project will cause bankfull channel to begin incision.	Longitudinal thalweg surveys. Bedrock contacts along the proposed channel centerline will be surveyed as part of the design phase, as-built channel thalweg will be surveyed to document elevation above bedrock contacts, and subsequent surveys will track whether (and how much) incision occurs after specific high flow events that exceed bed mobility thresholds	Compare longitudinal profiles and cross sections prior to and after high flow events to determine patterns of aggredation and deposition.	WSRCD Without removing Saeltzer Dam and/or manually adding coarse sediment, reconstructed channel not controlled by bedrock will again begin to incise during high flow events large enough to transport coarse bed material. This monitoring will document where incision occurs and how much. Moderate priority	Anticipated CALFED Grant

Table 1. **Ecological objectives, hypotheses, and study parameters for Lower Clear Creek Floodplain Restoration Project, Continued.**

II) Biological/Ecological Project Objectives for Geomorphology.				
OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
Objective G6: Recreate a properly sized alluvial channel morphology with adequate coarse sediment supply. Hypothesis G6: As the bankfull channel migrates, coarse and fine sediments will deposit on the inside of meander bend, creating a new functional floodplain.	The monitoring parameter will be bankfull channel width, bankfull channel depth, and perhaps estimates of bankfull channel boundary shear stress. These parameters will be obtained from cross sections installed throughout two alternate bar sequences (targeting meander bends.)	Evolution of cross section shape, dimensions, and perhaps boundary shear stress will be documented before and after discrete high flow events. Channel adjustment will also be considered in light of changing sediment loads, high flow magnitude, and high flow duration.	WSRCD Much of this will be collateral information gathered with other geomorphic monitoring activities. Channel dimension evolution will be used to improve future channel designs. Moderate priority.	Currently CVPIA, CALFED is anticipated future source.

Table 1. Ecological objectives, hypotheses, and study parameters for Lower Clear Creek Floodplain Restoration Project, Continued.

III) Biological/Ecological Project Objectives for Riparian Communities.				
OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
Objective R1: Restore native riparian vegetation on newly created floodplain surfaces. Hypothesis R1. The revegetation phase of channel restoration activities will increase the quantity and diversity of native riparian vegetation on reconstructed floodplain surfaces.	Map and describe the composition of riparian vegetation within the project study area prior to and after stream channel and floodplain restoration activities. Continue to monitor project site for a minimum five year period following the completion of restoration activities.	Planform Mapping: Construct maps of riparian vegetation coverage and compare riparian vegetation communities before and after restoration efforts. Cross Section: Establish cross sections and sample plots to monitor planting success, natural recruitment, species composition, distribution and density. Duplicate data collection efforts (cross sections, plots, mapping) at control sites located outside of project study area, monitor over time and compare results.	WSRCD Moderate Priority	CALFED funding is anticipated
Objective R2: Create favorable physical conditions for regeneration of native riparian species on restored floodplains. Hypothesis R2. Implementation of channel and floodplain restoration activities, combined with favorable hydrologic conditions during seed dispersal period, will increase natural regeneration of native riparian species on constructed floodplain surfaces.	Monitor natural recruitment of riparian species on newly created floodplain surfaces for a minimum of five years following completion of restoration activities.	Establish cross sections and sample plots on newly restored floodplains. Monitor natural recruitment of riparian vegetation. Compare recruitment, density, distribution and species composition to that observed at control sites.	WSRCD Moderate Priority	CALFED funding is anticipated

GEOMORPHIC MONITORING OBJECTIVES

Construction of Whiskeytown Dam, Saeltzer Dam and gravel extraction have significantly reduced the magnitude and frequency of natural fluvial geomorphic processes that are necessary to maintain healthy ecological functions in lower Clear Creek. Gravel excavation removed point bars, floodplains, and riparian vegetation, leaving an unconfined stream channel with multiple channels and numerous open extraction pits. In addition, gold dredging at the Reading Bar borrow site destroyed the floodplain and presently confines the low flow channel between dredger tailings.

The overall geomorphic objective at both the project site and borrow site is to create a single thread channel morphology that is properly sized to the anticipated future sediment transport and flow release regimes. To achieve this desired condition, the Restoration Team developed two basic questions to be addressed by geomorphic monitoring: (1) Are natural geomorphic processes being restored by the project (Restoration of Processes), and (2) how is the channel location and morphology adjusting during high flow events (Project Performance)? The first question addresses project performance as it relates to ecological and geomorphic restoration objectives, while the second addresses how well the channel was built by targeting critical channel locations most susceptible to undesired channel adjustment. For monitoring purposes these two basic geomorphic questions were further broken down into more specific process related objectives that can be readily quantified and evaluated.

Specific geomorphic restoration objectives include:

G1. Riffle matrix particles (D_{84}) are mobilized by design bankfull discharge (3,000 cfs)

G2. Bankfull channel migrates across floodway

G3. Bankfull channel capacity is 3,000 cfs; as flow exceeds 3,000 cfs, flow begins to spread across constructed floodplains

G4. Flows inundating floodplain to a depth > 1 ft causes fine sediments to deposit on floodplain.

G5. Introducing gravel via the restoration project will reduce bedrock exposure in the channel and upstream gravel augmentation will help maintain this condition.

G6. As bankfull channel migrates across floodway, point bars and new floodplains are formed as it migrates

Recall that two sites are being restored adjacent to the creek; the gravel mining reach project site, and the Reading Bar borrow site. All six geomorphic process objectives are adopted for the gravel mining reach project site; however, because the Reading Bar site will be strictly a floodplain and bank rehabilitation project, only Objectives 2, 3, 4, and 6 apply.

RIPARIAN MONITORING OBJECTIVES

Understanding that the overall goal of the project is to rehabilitate natural form and function of the stream channel and floodplain, the first step is to re-create the physical form of the channel and floodplain. Following completion if the initial step, riparian restoration objectives to help achieve the project goal include revegetation of reconstructed floodplains, promotion of natural regeneration/recruitment by creating favorable physical conditions for natural riparian regeneration, minimizing disturbance of existing riparian vegetation, and removal of exotic plant species within the project area.

The riparian revegetation component is as important to project success as proper geomorphic channel design. Riparian vegetation provides much of the terrestrial and aquatic habitat in healthy river ecosystems, while stabilizing riverbanks, dissipating floodwaters, trapping fine sediment, and creating hydrologic complexity that creates channel diversity. The long-term goal of the riparian revegetation component is to restore the extent, morphology, and dynamics of riparian vegetation within the floodway that can be maintained by the current flow regime. An additional short-term goal is to provide floodplain stability for the floodway rehabilitation project.

Wetland revegetation will include a combination of natural plant colonization (i.e., passive revegetation) and artificial planting (i.e., active revegetation). Natural plant colonization will be conducted by creating favorable physical conditions for natural regeneration, while artificial planting will occur on the emergent bench habitats by planting native emergent wetland plant species. Following removal of borrow material, the primary goal of creating off-channel wetlands is creation of higher quality wetland habitats than those currently existing on-site and throughout the lower Clear Creek corridor that resulted from historic gold and gravel mining disturbances.

Restoration areas occur along portions of the project site and at each borrow site. These areas include locations for both natural colonization and active planting efforts. The Project Site consists of approximately 70 acres of riparian planting areas, 23 acres that will be part of the restored active Clear Creek stream channel, and approximately 100 acres of frequently flooded floodplain surfaces left for natural riparian plant recolonization. The Reading Bar borrow site consists of approximately eight acres of riparian planting areas, a 0.30 acre emergent wetland, and approximately15 acres that will be part of the restored active Clear Creek stream channel and/or open areas left for natural plant recolonization. The Former Shooting Gallery borrow site will consist of approximately 11 acres of riparian planting areas, approximately three acres of emergent wetland, approximately seven acres of open water wetlands, and 36 acres for natural plant recolonization.

The revegetation goal is to encourage natural regeneration wherever possible, while revegetating where necessary, to restore riparian vegetation coverage and complexity on lower Clear Creek. Monitoring efforts will focus not only on the revegetation success, but also on how revegetation develops into a multiage, structurally diverse and species rich riparian forest. Specific objectives related to riparian stand function and recovery are:

R1. Restore native riparian vegetation on newly created floodplain surfaces by planting patches of native riparian hardwoods on surfaces that are inundated at a frequency appropriate for each species life history requirements. The hydraulic roughness on the outside bends of the floodplain will be elevated at critical locations to reduce the potential of catastrophic channel avulsion immediately following construction.

R2. Promote natural regeneration/recruitment on reconstructed floodplains, by creating areas where favorable physical conditions for natural riparian hardwood regeneration can evolve.

MONITORING ENTITIES AND EXPERIENCE

Monitoring efforts are anticipated to include multiple agencies, environmental consulting firms, academia, and resource volunteers working cooperatively under the guidance of the WSRCD, BR, USFWS, Bureau of Land Management (BLM), and California Department of Fish and Game (CDFG). Fishery resource monitoring elements will be conducted by USFWS offices in Red Bluff and Sacramento. The WSRCD will be responsible for implementation of monitoring elements identified for the riparian and geomorphic monitoring parameters. McBain and Trush, fluvial geomorphologists, and North State Resources, Inc., consulting environmental scientists, assisted the WSRCD in the development of specific monitoring plans for riparian and geomorphology. A more thorough description of monitoring entities relative to fishery resources, geomorphology, and riparian habitats are discussed below.

FISHERY RESOURCES

The U.S. Fish & Wildlife Service's Ecological Services Division Instream Flow Branch in Sacramento and the Northern Central Valley Fish and Wildlife Office in Red Bluff will work cooperatively to conduct the fishery resources monitoring effort.

Mark Gard PhD, is the Instream Flow Branch Chief for the U.S. Fish and Wildlife Service and will supervise data collection and habitat modeling efforts described under element F1 of the monitoring plan. Mark is a recognized expert in the use of IFIM and has over 10 years of experience in fisheries research.

Mr. Matt Brown received a Bachelors of Arts Degree in Biology from the University of California at Santa Cruz in 1986 and a Master of Science Degree from Arizona State University in 1990. He worked as a non-game fish biologist for the Arizona Game and Fish Department from 1990 to 1991. He worked for the Fish and Wildlife Service on threatened and endangered fish in New Mexico from 1991 to 1993. Matt began work on chinook salmon at the Northern Central Valley Fish and Wildlife Office in January 1994. His current work focuses on habitat restoration under the Central Valley Project Improvement Act and evaluating the impacts of water development. Matt Brown will assist and coordinate with Mark Gard's habitat modeling efforts and will supervise monitoring of juvenile stranding and adult passage.

GEOMORPHOLOGY AND RIPARIAN VEGETATION

The WSRCD will be responsible for implementation, coordination and management of project monitoring efforts for the riparian and geomorphology elements of the Monitoring Plan. Mr. Jeff Souza is currently the Projects Manager for the Western Shasta Resource Conservation District (RCD) in Redding and has been with the RCD for the last four years. He has a Bachelor of Science degree in Environmental Biology from California Polytechnic State University, San Luis Obispo and a Masters degree in Agriculture from California State University at Chico. Jeff is a native of the northern Sacramento Valley and has been working in the fields of resource management and restoration for over ten years. As Projects Manager for the RCD, Jeff has successfully managed over two dozen projects in the areas of wildlife and fisheries restoration, erosion control, fuels reduction, and coordinated resource planning.

MONITORING DURATION, CONSTITUENTS, AND METHODS

FISHERY RESOURCES

Objective F1- Improve salmonid rearing and spawning habitat within the project reach.
Modeling of spawning and rearing habitat will occur in the restoration site prior to and after restoration actions are completed. Restoration actions are currently scheduled to begin in the summer and fall of 1999 with the initiation of Phase 2. Completion of Phase 4, which is the final Phase, is planned to occur in the summer of 2001. Prior to implementation of restoration activities (Spring of 1999) USFWS will conduct a field reconnaissance survey to determine specific study site boundaries, transect locations and develop meso-habitat maps. Hydraulic data on water surface elevations, bed topography, cover and substrate will be collected for input into a 2-dimensional hydraulic and habitat model. Following construction and calibration of hydraulic data sets the 2-dimensional model will be used to predict water velocities and depths present in

the study site over a range of discharges that are likely to occur within study site under future flow release conditions. This output, along with the substrate and cover distribution in the site and Habitat Suitability Criteria previously developed on Clear Creek or other streams, will be used to predict the amount of spawning and rearing habitat present over a range of discharges in the restoration site prior to restoration actions.

Implementation of restoration actions will create a new channel alignment and floodplain throughout the project site. Therefore, a second survey (2002) will be required to map habitat conditions and identify new transect locations. Hydraulic data on water surface elevations, bed topography, cover, and substrate will be collected for the restored channel configuration for input into a 2-dimensional hydraulic and habitat model. Data sets will then be assembled for input and calibration of the 2-dimensional hydraulic model. Following model calibration, the 2-dimensional model will be used to predict water velocities and depths over a range of expected flows. This hydraulic output will then be used with cover and substrate distribution data and Habitat Suitability Criteria to predict the amount of salmonid spawning and rearing habitat present within the study site under restored conditions.

A Final Report will be completed at the end of the study comparing the amount of rearing and spawning habitat for a range of discharges present in the study site before and after restoration actions. Habitat comparisons will be conducted for fry, juvenile and spawning life stages of chinook salmon and steelhead trout. Information developed from this study may result in additional restoration recommendations and may assist in development of flow release patterns.

Objective F2- Reduce juvenile salmonid stranding mortality.

The current degraded conditions of the lower Clear Creek channel create favorable conditions for stranding juvenile salmonids. USFWS and CDFG have documented stranding of juvenile salmonids in several locations within the Project Site. Implementation of channel and floodplain restoration actions is expected to reduce stranding mortality. To evaluate the success of the restoration effort the USFWS will continue existing surveys of the project site through implementation of the project. A description of survey methods follows.

The USFWS's Northern Central Valley Fish and Wildlife office currently conducts surveys to document the occurrence of salmonid stranding throughout the Project site. The entire Project site topography has been mapped and digitized aerial photographs are used to depict locations of all potential stranding sites. Each potential stranding site has been described based on location, physical characteristics and hydrology (isolated pond, inundated at high flow, or connected to main channel).

Pedestrian surveys are conducted of the entire Project site by qualified biologists throughout the rearing season. Data recorded for each survey include date, time, Clear Creek Flow, and weather conditions. Observations recorded during each survey for each location include: 1) presence of juvenile chinook salmon at each location; 2) qualitative estimate of the number of juvenile chinook salmon observed; 3) description of current hydrologic characteristics; and, 4) water temperature.

New project topographic maps and aerial photographs will be developed following completion of the restoration project. USFWS biologists will survey the project site during periods of high flow and throughout the juvenile rearing season to identify and map potential stranding locations that may exist under restored conditions. Should potential stranding locations exist, USFWS will continue surveys, quantify the magnitude of the stranding problem and develop potential solutions for recommendation to the Lower Clear Creek Restoration Team.

Because restoration efforts are designed to restore natural fluvial processes through creation of a dynamic channel morphology, channel migration is expected to occur over time. However, if the restored channel is not in balance with future flow and sediment transport rates there is a potential that major channel migration could occur during flood events. Should large scale shifts in the location of the channel be observed USFWS will again survey the project area and document potential stranding locations.

Annual progress reports will be submitted to the Restoration Team and CALFED describing survey methods, frequency of surveys, and results. A final report will be submitted to the Lower Clear Creek Restoration Team one year after construction of the restoration project. The final report will describe survey methods, summarize annual survey results, and compare stranding conditions prior to and after restoration.

Objective F3- Improve adult passage conditions through the project reach upstream.
The existence of braided channels and gravel extraction pits in and adjacent to the creek channel may hinder passage of adult salmon upstream during low flow. To document impacts to adult passage the Northern Central Valley Fish and Wildlife office will visual assess adult salmon passage conditions during upstream migration over critical riffles within the project site prior to implementation of restoration efforts. If passage problems are observed, problem areas will be mapped and evaluated in more detail as follows. Transects will be established across critical riffles to collect hydraulic data (water depth, velocity, water surface elevation and discharge) to fully describe existing passage conditions.

After restoration of the project site is completed USFWS biologists will again visually assess adult passage conditions through the site. Should passage problems be observed transects will be established at each location and hydraulic data collection efforts will be repeated. Additional hydraulic data will then be collected under different flow release conditions for development of hydraulic models to describe the relationship between passage conditions and stream discharge for each critical riffle within the restored channel. Results of hydraulic modeling, will provide information to assist development of recommendations to correct passage conditions through implementation of mechanical restoration actions or improved flow releases. Hydraulic modeling efforts for fish passage will be coordinated with hydraulic and habitat modeling efforts described under Objective F1.

A final report will be submitted to the Restoration Team and CALFED describing the effectiveness of restoration actions to improve fish passage conditions. The report will include detailed descriptions of methods used, results, and recommendations for corrective measures if necessary.

GEOMORPHOLOGY

Objective G1-Riffle matrix particles (D_{84}) is mobilized by design bankfull discharge (3,000 cfs). The bankfull channel morphology was designed so that the D_{84} particle size in riffles would be just mobilized by the design bankfull discharge (3,000 cfs). Bed mobility models were used to predict the channel dimensions necessary for a 3,000 cfs flow to mobilize the D_{84} particle size. In the two long-straight riffles shown on Plate 1, tracer rocks representing the local D_{84} particle size (and other particle sizes) will be used to evaluate whether bed mobility objectives are being met in the design channel. Cross sections will also be established through two alternate bar sequences, which will include cross sections and marked rocks through point bars, pool tails, and riffle crests to document bed mobility on other geomorphic features. Surface pebble counts will be collected for as-built conditions, and marked rocks inserted at many cross sections shown on Plate 1. After each peak flow larger than 2,000 cfs, the marked rocks will be monitored. We expect changes in particle size as the constructed bed surface adjusts during high flows, therefore, after the first water year, we will re-document particle size with repeat pebble counts, and set out new sets of tracer rocks. Tracer rocks in subsequent years will be monitored after each peak flow greater than 2,000 cfs. The objective is to determine if D_{84} tracer particles are being mobilized by flows up to and exceeding the design bankfull discharge (3,000 cfs).

Objective G2-Bankfull channel migrates across floodway.
As-built topographical surveys will be conducted as part of construction implementation verification; cross section pins established at the end of construction will serve as long-term cross section monitoring endpoints. Ground level photographs will be taken of each cross section and aerial photographs will be flown after construction to document as-built conditions at both the project site and Reading Bar borrow site. Using the tracer rocks as an indicator of bed movement and potential for channel migration, cross sections will be resurveyed after flows that mobilize the tracer rocks. Subtle channel migration will be documented by these repeat cross sections, while repeat aerial photographs will be used to document more dramatic shifts in channel location. Ground level photographs and aerial photographs will be re-taken every three years or after a high flow that causes dramatic changes to channel morphology, whichever is sooner.

Objective G3-Bankfull channel capacity is 3,000 cfs; as flow exceeds 3,000 cfs, flow begins to spread across constructed floodplains.

The bankfull channel morphology was also designed to convey the design bankfull discharge (3,000 cfs); flows larger than 3,000 cfs should begin to spill onto the floodplains. The HEC-2 hydraulic model was used to develop the channel dimensions at the gravel mining reach project site to achieve this objective, while at the Reading Bar site, we were fortunate to have monitored water surface profiles during a 2,900 cfs flow, so design floodplain elevations should be very accurate. Monitoring water surface elevations on cross sections through both the project reach and Reading Bar reach during 3,000 cfs magnitude flows will evaluate whether this conveyance objective is being met. This will be conducted at all sampling sites shown on Plate 1. At the Reading Bar borrow site, eleven cross sections were established in 1998 to monitor Phase 1 reclamation (these are not shown on Plate 1). These cross sections will continue to be monitored and ground level photographs taken to evaluate final reclamation of the Reading Bar site as Phase 2 is implemented.

Objective G4-Flows inundating floodplain to a depth > 1 ft causes fine sediments to deposit on floodplain.

Streams typically transport most of their sediment load (up to 95 percent) as finer sediments suspended in the water column during high flows. Under natural conditions, a large proportion of this fine sediment may deposit on floodplain surfaces, which creates seed-beds for riparian regeneration and reduces fine sediment deposition within the bankfull channel. Stream reaches downstream of a large storage reservoir (e.g., Whiskeytown Dam) often have very little fine sediment transported in suspension because the reservoir traps sediments derived from the upstream watershed. We are concerned that the finer components of the suspended sediment load (<0.1 mm) in Clear Creek is small due to Whiskeytown Dam, which will reduce fine sediment deposition on floodplain surfaces. We will monitor fine sediment deposition on floodplains by taking detailed elevation measurements and photographs at a subset of the cross sections shown on Plate 1. Surveys will be conducted before and after high flow events that inundate the floodplains, and water surface elevations will be monitored to evaluate whether there is a depth threshold for fine sediment deposition. Detailed elevation measurements will also be conducted at selected permanent vegetation plots shown in Plate 2. This information will be used in conjunction with the riparian monitoring to evaluate potential correlations between natural riparian regeneration and areas of fine sediment deposition.

Objective G5-Introducing gravel via the restoration project will reduce bedrock exposure in the channel and upstream gravel augmentation will help maintain this condition.

Gravel mining and the impact of upstream dams in reducing coarse sediment supply have cumulatively caused channel downcutting in the reach, and increased exposure of clay hardpan bedrock in the low flow channel. Because salmon cannot spawn in bedrock, and aquatic insect production in bedrock is low, raising the channelbed above the bedrock by massive gravel introduction will greatly improve aquatic habitat conditions. Our primary concern is, because Whiskeytown Dam will continue to trap coarse sediment from the upstream watershed into the future, the restoration site will begin downcutting a short time after project completion. Removal of Saeltzer Dam and continuing the gravel introduction program will reduce the risk or degree of downcutting, but it still may occur. The primary method of monitoring channel grade through the reach will be collective cross sections, thalweg profiles through the entire reach, and substrate mapping at the alternate bar monitoring sites supported with photographs of each site (Plate 1). Monitoring will again be triggered by flows that exceed bed mobility thresholds, as described under other objectives. In addition, we will continue measuring coarse sediment transport in Lower Clear Creek, but move the sampling site to a reach immediately upstream of the gravel mining reach project site (Plate 1). This sampling will provide empirical sediment transport input for applying a HEC-6 bedload transport model for predicting scour and fill at the project site, and evaluating how well the model predicts scour and fill compared to actual channel response.

Objective G6-As bankfull channel migrates across floodway, point bars and new floodplains are formed as it migrates.
As a stream migrates across the floodway, they build bars and floodplains on the inside of the migrating meander bend. This floodplain formation is not solely dependent on the channel migrating; an upstream sediment supply is needed to physically construct the point bar and floodplain on the inside of the bend. Restoration efforts on lower Clear Creek (including this project) will continue to add coarse sediment to the stream corridor to help create and maintain point bars and floodplains. Cross sections will again be the foundation for monitoring whether this objective is being met. At the two alternate bar monitoring sites and Reading Bar borrow site, cross sections will be established/monitored at certain locations where migration is expected to occur: at the outside of meander bends. In addition photo monitoring sites will established at each cross section. This monitoring will repeat the methods used to evaluate Objective 3, except that it will focus on the inside of the bend (in the depositional area) rather than the outside of the bend (erosional area).

Project Performance Objectives

There are two primary project performance objectives:

1. Provide short-term stability at two critical meander bends to prevent immediate channel recapture into old location

2. Design channel should convey bankfull discharge (3,000) cfs before spilling onto floodplain.

Evaluating these two objectives, the six geomorphic process objectives, and riparian vegetation objectives described in later sections, requires an accurate measure of streamflow to establish cause and effect relationships between stream response and discharge. Therefore, streamflow monitoring is also described below.

Short-Term Stable Meander Bends

The overarching geomorphic objective of the project is to restore the ability of the channel to move sediment, adjust its dimensions, and migrate across the floodway. However, we would prefer, at least for the first five years while the riparian vegetation grows, that the channel remain relatively stable in two locations within the project reach where the stream is susceptible to re-occupy its pre-restoration channel. These locations are at Stations 214+00 and 180+00 on Plate 1. In these two locations, cross sections will be established through the apex of the meanders to monitor lateral migration, bank undercutting, and adjustments in channel morphology.

Hydraulic Conveyance

Channel geometry to convey the design bankfull discharge is a primary design objective. As flows begin to exceed 3,000 cfs, flow should begin to inundate floodplain surfaces and deposit fine sediments being transported in suspension. If flows exceeding 3,000 cfs are still contained within the bankfull channel, then higher than designed for shear stresses could occur, causing larger bedload transport rate, increased risk of channel downcutting, and increased risk of habitat loss. A HEC-2 water surface profile model was used to help design the bankfull channel dimensions to convey the design bankfull discharge; it will also be used to evaluate hydraulic conveyance performance. At all cross sections shown on Plate 1, water surface elevations for distinct high flow events will be monitored and compared to floodplain elevations. These cross sections will also be included in the HEC-2 model, and the roughness values in the HEC-2 model can be calibrated to improve the predictive capability of future designs.

Streamflow Gaging

Evaluating the response of the channel to a given flow requires two additional measures in addition to measuring the response itself: the magnitude of the flow that caused the channel response, and the flood frequency of that flood for perspective. For example, we would not expect the channel to avulse across the floodway during a 1.5 year flood, but would expect the bed surface to be mobilized. Long-term streamflow gaging has been conducted by USGS at the Igo gaging station a few miles upstream, and this gage will provide the primary flow measurement point for evaluating the project. We have installed a second continuous recording gaging station at the downstream end of the project site (see Plate 1) to provide more local flow data and serve as a backup to the USGS gaging station. In addition, we have installed and will continue to monitor four staff plates installed throughout both the gravel mining restoration site and Reading Bar borrow site to document local water surface elevations for a given discharge.

Monitoring Schedule and Reports

All data and reports will be available in electronic format, and will be archived on CDROM for distribution to interested parties. Cross section, longitudinal profile, and most other field data will be entered and archived in Microsoft Excel spreadsheets. Planform maps will be digitized into and archived in AutoCAD using NAD 1927 horizontal and vertical datum.

Because geomorphic processes occur during high flow events in the fall and winter, progress reports will be prepared at the end of the fall/winter high flow season (June). Monitoring at the Reading Bar borrow site will begin in the winter of 1999/2000, while monitoring at the project site will not occur until Phase 3 is completed in the fall of 2001. Therefore, progress reports will be produced as follows:

June 2000: Reading Bar borrow site year 1 progress report.
June 2001: Reading Bar borrow site year 2 progress report.
June 2002: Reading Bar borrow site year 3 progress report, Phase 3 project site year 1 progress report.
June 2003: Phase 3 project site year 2 progress report, Phase 4 project site year 1 progress report.
June 2004: Phase 3 project site year 3 progress report, Phase 4 project site year 2 progress report.

A final report of geomorphic monitoring at the project site and Reading Bar borrow site will be completed by December 2004 provided project implementation occurs on schedule. Should delays in the implementation schedule occur the geomorphic monitoring schedule will be adjusted accordingly.

Riparian Vegetation

Objective R1-Restore native riparian vegetation on newly created floodplain surfaces by planting patches of native riparian hardwoods on surfaces that are inundated at a frequency appropriate for each species life history requirements. The hydraulic roughness on the outside bends of the floodplain will be elevated at critical locations to reduce the potential of catastrophic channel avulsion immediately following construction.

Some riparian plant species are sensitive to inundation (Fremont cottonwood, Oregon ash, etc.) while others are more sensitive to deposition (white alder). These sensitivities, combined with seed dispersal times are often the major physiologic factors driving vegetation patterns adjacent to streams; in regulated rivers these relationships lead to riparian vegetation encroachment. Plant success after revegetation will be determined by whether planted riparian hardwoods were thriving in their planted environments. Riparian plant recruitment into revegetated floodplains should be similar in composition to revegetated stands in the same inundation regime. A thriving riparian stand will have an increasing canopy cover and understory that is increasing in species richness, while riparian encroachment into the low water channel should be nonexistent.

To evaluate revegetation development, 10 meter radius circular plots will be established within each patch type planted, and band transects will be used (Bonham 1989, Kent and Coker 1992). Circular plots shall be randomly placed within any of the patches of a specific patch type using CAD software. The number of randomly sampled circular plots is determined by the total area of each patch type planted within a construction phase divided by 2 acres (Figure 2). Because plot number is determined by the *total area* of a patch type, some patches do not have circular plots. For example, if a singular patch is smaller than the radius of the circular plot it will not sampled, or if the total acreage of a patch type is less than 2 acres only one circular plot will be used. Within each circular plot, plant species, each species estimated percent cover, maximum and average height, youngest, and oldest hardwood age, stem number (for hardwoods < 7.5cm) and diameter at breast height and stem number (for plants > 7.5 cm) will be measured. Photo monitoring will also occur at each circular plot to help document conditions. Additionally, permanent 2 meter wide band transects will be sampled along valley wide cross sections established in alternate bar reaches during geomorphic sampling, and along cross sections where piezometers have been established (Figure 2). Plant species, estimated plant species cover, hardwood age class, average and maximum canopy height, substrate transitions, and visible soil moisture will be quantified during band transect sampling. Photo monitoring stations will also be established across each cross section to help describe changing conditions to riparian vegetation through the monitoring period.

Fine sediment deposition during floods is a response to elevated hydraulic roughness over floodplains caused by maturing riparian vegetation. Fine sediment accumulation is an important ecosystem process on floodplains because it promotes the development of seed beds where regeneration can occur and provides richer soils for the needs of plants that can not live closer to the channel where substrate is coarser and where groundwater is more responsive to rapid drops in river stage. As fine sediment continues to deposit channel confinement increases, which leads to greater pool depths and fish habitat complexity.

Sediment deposition and channel confinement related to vegetation will be monitored using a combination of square permanent plots and previously established band transects. Permanent 10 x 10 meter plots will be established on floodplains and in scour channels to evaluate sediment deposition (Plate 2). Substrate composition, stem density within the plot and upstream from the plot (or in the direction of flood flow), plant growth habits, plant species, and substrate size will be evaluated.

Objective R2-Promote natural regeneration/recruitment on reconstructed floodplains, by creating areas where favorable physical conditions for natural riparian hardwood regeneration can evolve.

Riparian hardwood recruitment is vital to the perpetuation and structural diversity within riparian vegetation. Riparian rehabilitation success could be easily gauged in an ecosystem context by the presence or absence of willow and cottonwood seedlings, and the reduction of riparian vegetation encroachment. Not only is fine sediment deposition important for seedling recruitment, but hydrologic conditions in the year of germination and subsequent years must provide the water that developing seedlings need without scouring or in some other way killing them. If recruited plants cannot be semi-annually scoured from within the active channel riparian vegetation will begin to encroach in the rehabilitated channel. While the project has some control over the physical conditions leading to successful hardwood recruitment on floodplains and reducing riparian encroachment, the project has no control over where and how much fine sediment will deposit, and over what annual flood magnitudes/timing and flow recession rates sedimentation occurs.

Data collected while monitoring objective R1 will be used to evaluate hardwood recruitment and encroachment. Groundwater elevations in piezometers will be monitored and related to changes in river stage, which will complement band transect based vegetation data. Evaluating the groundwater river stage relationship will help in understanding the physical variables that relate to the presence (or absence) of naturally recruited hardwoods.

Exotic plants pose the greatest threat to riparian rehabilitation success. Exotic plants could potentially out compete plantings and colonize open areas where natural recruitment could occur. If post project conditions favor exotic plant species over native hardwoods, than the environmental conditions that promote exotic species over natives will be evaluated. Micro-climatic measurements of relative humidity and air temperature will be taken within all monitoring plots using a sling psychrometer. Trends in species composition will be evaluated in context to geomorphology, distance from the active channel, and microclimate. Additionally, data collected while monitoring objective R1 will be used to evaluate exotic plant species success, recruitment, and inter/intra specific competition that could lead to the exclusion of native hardwood species.

Monitoring Schedule and Reports

Monitoring will begin immediately following the revegetation of each construction phase. Monitoring will occur again towards the end of each growing season in October for a period of five years. Progress reports will be produced as follows:

June 2000: Reading Bar and Phase 2a site as-built report
January 2001: Reading Bar and Phase 2a 1-year progress report, and 2b site as-built report
January 2002: Reading Bar and Phase 2a 2-year progress report, Phase 2b 1-year progress report, and Phase 3 as-built report
January 2003: Reading Bar and Phase 2a 3-year progress report, Phase 2b 2-year progress report, Phase 3 1-year progress report, and Phase 4 as-built report
January 2004: Reading Bar and Phase 2a 4-year progress report, Phase 2b 3-year progress report, Phase 3 2-year progress report, and Phase 4 1-year progress report

A final report of riparian monitoring at the project site and Reading Bar borrow site will be completed by December 2004 provided that implementation occurs on schedule. Should delays in the implementation schedule occur, the riparian monitoring schedule will be adjusted accordingly.

QUALITY ASSURANCE PROJECT PLAN

All field data collection will occur under the supervision of qualified resource professionals, i.e. fish and wildlife biologists, geomorphologists, botanists, and/or engineers where appropriate. All work conducted on this design to date has used State Plane Coordinate System and NAD 1927 datum; future monitoring will continue this standard. Because this base control has been established by licensed surveyors, vertical and horizontal accuracy should continue to be excellent. Cross sections and longitudinal profiles will be collected by skilled technicians with an engineers level, which provide excellent vertical accuracy. Data will be recorded in hardbound water-resistant transit books, and study site setup, survey, and field note recording will follow standard stream monitoring protocols published by Harrelson et al., 1994. Field data will be entered into Excel spreadsheets by a member of the survey crew, and independently reviewed by a senior member of the survey crew for quality control.

REFERENCES

Harrelson, C.C., Rawlins, C.L., and Potyondy, J.P. 1994. *Stream channel reference sites:an illustrated guide to field technique.* Gen. Tech. Rep. RM-245. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61p.

MONITORING OF MERCURY LOAD FROM RESTORATION ACTIVITIES

APPROACH – MERCURY SAMPLING AND INTERPRETATION

Tetra Tech will conduct mercury sampling, data reduction, and data interpretation for the Western Shasta Resource Conservation District's three (3) year mercury monitoring program on Lower Clear Creek. The specified objective of this monitoring program is to determine whether the stream restoration activities undertaken by WSRCD and its' partners in Lower Clear Creek have affected the load of mercury discharged. The proposed Tetra Tech project manager is Dr. Ted Donn.

Field Sampling

Surface water sampling will be conducted at two stations, one above, and one below the restoration project area. These sampling locations will be collocated with existing (GMA gage CC3A), or soon to be installed (Phase 4), Graham Matthews Associates geomorphology stations (Figure 5). These stations will be sampled during six flow events each year for a period of three years. The six events each year will consist of:

- Three storm events. These events are designed to capture mercury and particle transport during those conditions during which the bulk of the sediment transport occurs (Pittman and Matthews 2004). The high flow (storm) sampling events will be coordinated with the sediment sampling conducted by Graham Matthews Associates to ensure comparability of data, and safety of the sampling crews..
- Two low flow events, including one late spring event and one fall (September) event. It is anticipated that the late spring event would occur before the thermocline has become established in Whiskeytown Reservoir. The fall sampling event would occur shortly before the reservoir turns over in the late summer or fall, and during the period when Chinook salmon have entered the system to spawn and flows are increased. Discharges from below the thermocline are expected to have the highest methylmercury concentrations likely to be encountered from reservoir releases at this time.
- One floating event. This event will be used to collect data during unusual conditions such as a glory hole spill or release of flushing flows.

Seven (7) surface water samples will be collected will be collected from areas in the stream where flow is greatest, generally in the thalweg at about 2/3 maximum water depth. This region typically has the highest suspended sediment load. Depending on stream conditions, samples may be collected at intervals across the stream at each sampling station using "ultra-clean" sampling techniques by experienced Tetra Tech staff. Based on available data, the average total unfiltered mercury concentration in Lower Clear Creek is low, approximately 1.4 ng/L in low flow and 5 ng/L in high flow conditions (Ashley unpublished data from 2001 to 2003). These data were used to estimate the required sample size. A sample size of 7 is expected to allow detection of a difference in the mean values between the upstream and downstream stations of 50 to 60 percent of the mean with a power of 70 percent at a confidence level of 0.05, for a single sampling event (Tetra Tech 1986; Tetra Tech, Ross & Associates, and EOA, Inc. 2000).

As the number of sampling events increases, the power to detect differences will increase. After the first year of sampling, the sampling design will be re-evaluated and the number of samples adjusted as necessary.

Laboratory Analysis

Each sample will be analyzed for total mercury (filtered and unfiltered) and total suspended solids. These data will be correlated with data on flow and turbidity concurrently collected by Graham Matthews Associates. In addition, methylmercury determinations will be conducted on two (2) samples from each station to determine the relationship between total mercury, methylmercury, and particulates. In conjunction with the hydrologic and geomorphic data generated by Graham Matthews Associates, these data could be used to calculate mercury loads entering and exiting the restoration area.

Data Evaluation and Reporting

Analytical data reports, with minimal interpretation, will be provided to WSRCD after each sampling event. The associated report would consist of basic statistical analyses of the data from the sampling event and a short summary. Tetra Tech will prepare an annual report summarizing the results of all sampling conducted during the previous year. This report will provide data tables and the results of statistical analyses to assess impact of the restoration project. Recommendations for any changes in the monitoring program will also be provided. The Tetra Tech project manager will attend three (3) TAC meetings each year to present the results of the monitoring program and address any comments or proposed changes.

Costing Assumptions

The estimated costs for the three year monitoring period are $230,000. A breakdown of costs is provided in the attached table. These costs are based on the following assumptions:

1. Three year study.
2. Six sampling events per year.
3. Each sampling event takes 2 days for a field crew of 2 persons.
4. The project manager will attend 3 TAC meeting per year to report results..
5. The cost proposal does not include annual escalation in salaries or analytical costs.

Analytical costs are based on use of laboratories that have previously conducted low level mercury analyses for Tetra Tech projects. Some cost savings may be achieved by leveraging WSRCD’s status as a governmental entity to obtain better analytical costs through an alternative CalFed approved laboratory. Tetra Tech will investigate costs from alternative laboratories.

References

Ashley, R. Unpublished data. 2001 to 2003 surface water sampling results from Lower Clear Creek. USGS, unpublished data.

Pittman, S. and G. Matthews. 2004. *Clear Creek Floodplain Rehabilitation Project, Shasta County, California: WY2004 Geomorphic Monitoring Report*. Prepared for: Western Shasta Resource Conservation District, Anderson CA. Prepared by: Graham Matthews & Associates, Weaverville, CA. June 2004.

Tetra Tech. 1986. T*echnical Support Document for ODES Statistical Power Analysis*. Prepared for: Marine Operations Division, Office of Marine and Estuarine Protection, U.S. Environmental Protection Agency.

Tetra Tech, Ross & Associates, and EOA, Inc. 2000. *Task 10, Copper Action Plan*. Sponsored by: City of San Jose, and Copper Development Association.

Western Shasta Resource Conservation District
MERCURY SAMPLING IN LOWER CLEAR CREEK; SHASTA COUNTY, CA

Field Sampling

Labor Category	Fully Burdened Rate		Hours		Cost
Project Manager	$125.00		72		$9,000.00
Principal	$120.00		0		$0.00
Senior Engineer/Scientist	$100.00		360		$36,000.00
Staff Engineer/Scientist	$75.00		432		$32,400.00
Associate Engineer/Scientist	$60.00		0		$0.00
Project Administration	$80.00		36		$2,880.00
Clerical/graphics	$55.00		0		$0.00
	Labor Subtotal:		900		$80,280.00
Other Direct Costs:					
Computer Usage	$1.16	/hour			$1,044.00
Hotel and per diem	$85.00	/day	36	days	$3,060.00
Mileage and tolls (6 events)	$0.375	/mile	7056	miles	$2,664.00
Courier services	$0	/event	18	events	$0.00
		Subtotal:			$6,768.00
	G&A at	11.94%			$808.09
Total ODCs					$7576.09
		Task Total			**$87,856.09**

Laboratory Analyses

Labor Category	Fully Burdened Rate		Hours		Cost
Project Manager	$125.00		18		$2,250.00
Principal	$120.00		0		$0.00
Senior Engineer/Scientist	$100.00		0		$0.00
Staff Engineer/Scientist	$75.00		36		$2,700.00
Associate Engineer/Scientist	$60.00		0		$0.00
Project Administration	$80.00		0		$0.00
Clerical/graphics	$55.00		18		$990.00
	Labor Subtotal:		72		$5,940.00
Other Direct Costs:					
Computer Usage	$1.16	/hour			$83.52
Laboratory analyses	$ 26,760.00	/year	3	years	$80,280.00
		Subtotal:			$80,363.52
	G&A at	11.94%			$9,595.40
Total ODCs					$89,958.92
		Task Total			**$95,898.92**

Data Evaluation and Reporting					
Labor Category	**Fully Burdened Rate**		**Hours**		**Cost**
Project Manager	$125.00		192		$24,000.00
Principal	$120.00		0		$0.00
Senior Engineer/Scientist	$100.00		0		$0.00
Staff Engineer/Scientist	$75.00		120		$9,000.00
Associate Engineer/Scientist	$60.00		0		$0.00
Project Administration	$80.00		12		$960.00
Clerical/graphics	$55.00		24		$1,320.00
	Labor Subtotal:		396		$35,000.00
Other Direct Costs:					
Computer Usage	$1.16	/hour			$459.36
Hotel and per diem (conference)	$100.00	/day	6	days	$600.00
Mileage and tolls	$0.375	/mile	3828	miles	$1,468.50
Courier services	$0.00	/report	3	reports	$0.00
Copying	$0.06	/page	240	pages	$14.40
		Subtotal:			$2544.26
	G&A at	11.94%			$303.43
Total ODCs					$2847.69
		Task Total			**$37,847.69**

PROJECT TOTAL:	**$221,602.70**

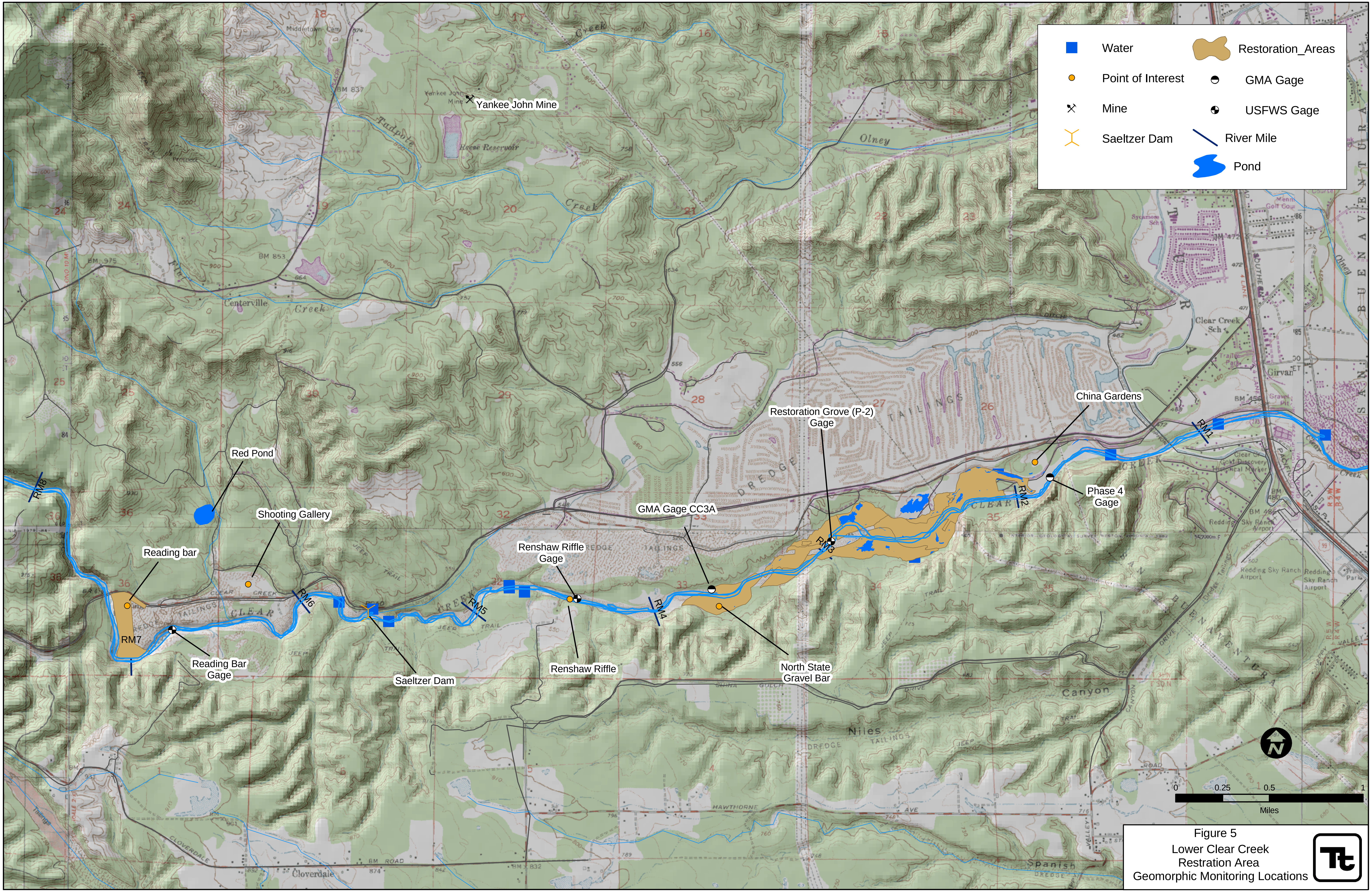

Figure 5
Lower Clear Creek
Restration Area
Geomorphic Monitoring Locations

SUMMARY SCOPE OF WORK FOR CLEAR CREEK BIOSENTINEL MERCURY MONITORING

Darell Slotton
Dept. of Environmental Science and Policy
University of California, Davis

The biosentinel approach to mercury monitoring has been recommended to the California Bay-Delta Authority (CBDA) in the Mercury Strategy as the optimal approach for measuring the key parameter of concern: relative methylmercury exposure. Young-of-year fish and certain invertebrates can provide accurate measures of this exposure through their bioaccumulation of methylmercury. Sampled carefully, these "biosentinels" can provide precise, statistically differentiable measures over time and between locations.

In the Clear Creek restoration work, as in most aquatic restorations in California, there is a need to measure the potential change in the production of methylmercury stemming from restoration actions. Monitoring of appropriate biological indicators will track the trend in relative methylmercury exposure and bioaccumulation in and around these sites.

The Environmental Mercury Laboratory at UC Davis has specialized, since 1991, in the research and monitoring of food chain methylmercury bioaccumulation. Projects have included the study of water, sediment, microbial methylmercury production, and a wide assortment of biota. Lower trophic level biota, particularly certain young-of-year fish and invertebrates, have proven to give the most useful measures of relative methylmercury exposure levels and uptake. Over the years we have refined the use of these biosentinel organisms such that we now can provide fine-scale, statistically differentiable measures of spatial and temporal variation. In research funded by CBDA, we have demonstrated strong statistical linkages between mercury levels in these test organisms and (1) mean methylmercury concentrations in the water and (2) mercury concentrations in corresponding large sport fish of human health concern. So, appropriate biosentinels sampled carefully can provide an integrated measure of local, recent aqueous exposure that also corresponds to sport fish mercury bioaccumulation. CBDA is relying on the biosentinel approach to monitor large new restoration projects throughout the Delta region. The UC Davis Slotton laboratory is developing and implementing that work. We propose to use these same techniques to monitor methylmercury exposure in relation to current and ongoing restoration efforts in the Clear Creek watershed.

US Fish and Wildlife Service has already determined that two small fish species are present across all or nearly all of the regions of focus: mosquitofish (*Gambusia affinis*) and California roach (*Hesperoleucas symmetricus*). Both can be useful biosentinels, based on prior work, particularly the California roach. These fish will be sampled at strategically located sites in and around the restoration areas. Each site sampling for each species will consist of numerous individuals to be analyzed individually and/or multiple composites, each composed of multiple individuals. This will provide extensive, tight replication sufficient to generate statistical confidence intervals around each mean mercury value. Biosentinel mercury can then be statistically compared both spatially among the carefully distributed sites, and within individual sites over time. Collections are proposed for twice each year: once toward the end of the cool season in the spring and again toward the end of the warm season in the summer or fall. Small fish biosentinels have been shown to integrate their exposure from the previous 1-6 months.

FIELD SAMPLING AND PRESERVATION TECHNIQUES

Fish will be collected with a variety of techniques including backpack electroshocker, seines, and, hand nets. Samples will be cleaned, separated by species, and frozen directly in the field in sealed Ziplock bags with water surrounding, using dry ice in field packs. With this preservation technique, virtually fresh condition has been demonstrated in samples thawed for analysis after up to at least 12 months. Small/juvenile fish samples will be analyzed whole body, either individually or in multiple composites, each containing multiple individuals. Whole body samples will be analyzed for total mercury, with methylmercury and the methyl:total mercury ratio additionally analyzed for each overall sample, using a composite prepared from equal portions of each individual or composite.

Riffle insects, if utilized, will be taken primarily with research kick screens. A variety of nets may also be used. Aquatic insect samples will be separated to the level of functional feeding group, which normally corresponds to the genus level. Each insect type will be separated into consistent multi-individual composites of whole individuals ($n \geq 30$ for small insects, $n \geq 10$ for larger insects), ideally collected in 3-4 unique replicates. The principal researchers will perform all separation of aquatic insects, ensuring proper taxonomic identification. Aquatic insect samples will be carefully cleaned of any surficial sediment directly at the collection site, using a technique of multiple transfers, with shaking, into successively cleaner water baths. Size range (length) will be determined and individual insects will be counted into pre-weighed, clean vials, one for each composite. Continuing at streamside, excess water will be consistently removed by inverting the vials over laboratory tissues. Average fresh/wet weight of the insects can then be later determined in the laboratory through weighing. All aquatic insect composite samples will be analyzed for methylmercury in addition to total mercury. Biotic samples of all types will be transported frozen on dry ice to the UC Davis Environmental Mercury Laboratory for analytical work

ANALYTICAL METHODOLOGY

Biological samples will be prepared and analyzed for total and methyl mercury at the UC Davis Environmental Mercury Laboratory. Small/juvenile fish samples will be analyzed whole body, individually or as multi-individual, whole body composites. Aquatic insects will be analyzed as multi-individual, whole body composites. The invertebrate multi-individual composites and whole small fish samples will be analyzed as dry powders for consistency. Moisture percentage will be carefully determined, through sequential weighings, to allow conversion to fresh/wet weight concentrations. Samples will be dried to constant weight at 55 °C and ground to a fine powder with either a modified coffee grinder (small fish) or Teflon-coated tools (invertebrates). Dry powder samples have proven ideal for reproducibility, sample archiving, and availability for ancillary analyses such as carbon and nitrogen stable isotopes.

Samples will be analyzed for total mercury by UC Davis with standard cold vapor atomic absorption (CVAA) spectrophotometry, using a Perkin Elmer Flow Injection Mercury System (FIMS) with an AS-90 autosampler, following digestion under pressure at 90 °C in a mixture of concentrated nitric and sulfuric acids with potassium permanganate. The detection limit for this method is typically 0.005 µg/g. The methyl:total mercury ratio will also be assessed for whole small fish and aquatic insect composite samples.
Methylmercury will be analyzed by UC Davis by complexation with bromide in a copper sulfate / sodium bromide solution, followed by organic extraction into methylene chloride / hexane, and then acid digestion and FIMS CVAA analysis as for total mercury. The detection limit for this method is typically 0.005 µg/g.

Moisture percentages will be determined using standard drying and sequential weighing technique.

QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

A rigorous program of QA/QC will be utilized throughout the project to ensure that accurate data are being generated. Standard field, preparatory, and analytical QA/QC will include the collection of numerous field replicate samples, careful preservation and assessment of actual moisture percentages of biotic samples, and extensive analytical split samples, spikes, spike replicates, calibration samples, blanks, laboratory control samples, and a range of standard reference materials with certified total mercury and methylmercury contents. Individuals of the same type and length, or replicate multi-individual composites function as field replicate samples for the analysis of sample organism variability at each sampling site. QA/QC samples are primarily tracked through the use of control charts, with warning limits set at two standard deviations away from the mean and control limits set at three standard deviations away from the mean. Samples will be preserved prior to analysis in carefully monitored laboratory freezers and refrigerators. Archived dry powdered samples will be maintained in individually labeled and tracked vials.

DATA REDUCTION

Following QA/QC verification, replicate sample data (individual small fish, replicate multi-individual fish composites, and replicate multi-individual insect composites) will be analyzed statistically by determining mean concentrations and 95% statistical confidence intervals for each type from each site-sampling. These shall be compared between corresponding samples from the different sites to assess statistical separation or similarity.

UC DAVIS BUDGET
CLEAR CREEK MERCURY MONITORING

Year	Salary	Benefits	Travel	Supplies	Service Contracts	Equipment	Total Direct	Indirect	TOTAL
1	$17,099	$5,985	$500	$1,500	$2,500		$27,584	$6,896	$34,480
2	$17,612	$6,164	$500	$1,500	$2,600		$28,376	$7,094	$35,470
3	$18,140	$6,349	$500	$1,500	$2,700		$29,189	$7,297	$36,487

Total 3 year budget: $106,437

LABOR	Labor costs = 0.35 FTE each year. Positions are 1) Principal Investigator (0.1 FTE); 2) Lab/Field/Data Manager (0.1 FTE); 3) Chemist(s) (0.15 FTE). Benefits are included at 35% of salaries.
TRAVEL	Travel costs include mileage reimbursements for use of personal vehicles for sampling, reconaissance, coordination, and presentations.
SUPPLIES	Includes supplies for field collections, sample handling and preparation, laboratory analytical work, computer and office work, publications, and presentations.
SERV. CONTRACTS	Primarily charges to accomplish 5% QA/QC split sample analyses by outside laboratory.
INDIRECT COSTS	CBDA indirect rate has been negotiated at 25%. Substantially higher indirect rate if not through CBDA.

I) Biological/Ecological Project Objectives For Avian Resources.				
OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
Objective A1: Create a functional riparian system during stream channel and floodplain restoration that supports highly productive populations of native avian species. Hypothesis A1: The revegetation phase and riparian floodplain dynamics created during channel and floodplain restoration will increase the productivity of a suite of riparian focal species above reference site levels.	Locate and monitor nests of a suite of riparian breeding bird species using established nationally standardized protocols. Vegetation data will be collected around each nest in order to link habitat features influencing nest success. Both restoration and reference sites will be monitored for 5 to 10 years post restoration.	The number of young produced per territory and/or Mayfield estimates of nest success at restoration and reference sites will be compared to determine productivity. Logistic regression will be used to evaluate the influence of habitat conditions on productivity and associate age of restoration with productivity.	PRBO High Priority	CALFED Monitoring PSP will fund all of the avian monitoring.
Objective A2: Create a functional riparian system during stream channel and floodplain restoration that supports higher densities of a suite of riparian breeding species than reference sites. Hypothesis A2: The revegetation phase of channel and floodplain restoration will increase the breeding densities of a suite of avian focal species on restoration sites over those of reference sites.	Map the breeding territories of a suite of focal bird species using established protocols at restoration and reference sites for 5 to 10 years post restoration.	Using standardized data of number of territories per 10 hectares we will compare the breeding densities on restoration sites to adjacent reference sites. Additionally, the change in densities and rate of change will be compared between restoration sites with different restoration design and features.	PRBO High Priority	

Objective A3: Create a functional riparian system during stream channel and floodplain restoration that supports high annual adult survival of a suite of riparian breeding species. Hypothesis A3: The creation of a functional riparian system will result in higher adult survival of a suite of riparian focal species.	Constant-effort mist netting following nationally standardized protocols will be conducted over a 5 to 10 year time frame to estimate adult annual survival for a suite of riparian breeding bird species at two sites at Clear Creek (conducted for 5 years through 2005).	Using the program MARK we will use Akaike's Information Criteria (AIC) to select the most appropriate model to estimate adult annual survival. Survival estimates will help refine objectives for nest success and provided a key component necessary for determining if breeding bird populations are sustainable at Clear Creek.	PRBO High Priority	
Objective A4: Create a functional riparian system during stream channel and floodplain restoration that supports a high diversity of riparian breeding bird species. Hypothesis A4: Restoration activities will result in restored sites combined supporting avian species richness equal to or above those levels of reference sites combined.	Using a nationally standardized point count protocol collect point count data throughout the project area at restoration and reference sites that have been monitored since 1999.	Using point count indices of species richness and/or ecological diversity we will compare treated sites and reference sites using one of several potential comparative statistical methods. We will also use linear regression to associate year since restoration with avian species richness.	PRBO High Priority	

II) Biological/Ecological Project Objectives for Geomorphology.				
OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
Objective G1: Recreate a properly sized alluvial channel morphology. Hypothesis G1: Coarse sediment will be mobilized by design bankfull flow (the bed moves)	The monitoring parameter will be percentage of tracer rocks mobilized for different alluvial features (point bars, riffles, pool tails, etc). Tracer rocks will be installed on at least two point bars and two riffles within the project reach, and monitored for mobilization and distance after each discrete high flow event sufficient to cause mobilization.	Tracer rocks will be evaluated by: 1) whether they moved, and 2) how far they moved. The former will allow us to evaluate whether the bed is mobilized by design bankfull discharge, and the latter will provide information on particle travel distance as a function of flow and duration of flow.	WSRCD Will allow designers to improve bankfull channel design for later projects. Moderate priority	Currently CVPIA, CALFED is anticipated future source.
Objective G2: Recreate a properly sized alluvial channel morphology. Hypothesis G2: The bankfull channel will migrate or avulse during flows approaching bankfull discharge and larger (the channel migrates)	The monitoring parameter will be bankfull channel location within the valley-wide cross section, and planform location over time. Cross sections will be installed throughout two alternate bar sequences (targeting meander bends). Post-construction aerial photographs will be rubber-sheeted and channel location digitized and overlain on previous channel locations.	Migration or avulsion of the bankfull channel will be evaluated by comparing channel response (feet moved, rate of movement) with the magnitude and duration of flow that caused the channel to migrate.	WSRCD Much of this will be collateral information gathered with other geomorphic monitoring activities. Moderate priority	Currently CVPIA, CALFED is anticipated future source
Objective G3: Recreate a properly sized alluvial channel morphology. Hypothesis G3: Flows exceeding design bankfull discharge will begin inundating constructed floodplains.	The monitoring parameter will be water surface elevation within the bankfull channel, and flow discharge for that water surface elevation. At one site assessable during high flows at the project site and borrow site water surface elevations will be predicted during the design phases, and elevations will be measured	Measured water surface elevations will be compared to constructed floodplain elevations, and hydraulic parameters will also be collected to refine hydraulic model.	WSRCD Will allow designers to improve bankfull channel design for later projects. Moderate priority	Anticipated CALFED Grant

II) Biological/Ecological Project Objectives for Geomorphology.				
OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
	during high flow events after construction.			
Objective G4: Recreate a properly sized alluvial channel morphology. Hypothesis G4: Flows exceeding design bankfull discharge will begin depositing fine sediments (sand and silt) on constructed floodplains	The monitoring parameter will be water surface elevation within the bankfull channel, flow discharge for that water surface elevation, and fine sediment deposition on floodplains At one site accessible during high flows at the Borrow Site and Project Site water surface elevations will be measured during high flow events after construction, and a depth flow threshold for fine sediment deposition will be sought.	Water surface elevations will be compared to constructed floodplain elevations (to get water depths); then, fine sediment deposition will be measured by cross sections and scour nails, and sediment composition will be documented by bulk substrate sampling. The source of the high flow (tributary derived vs dam spill) will be considered and when feasible (safe), depth integrated suspended sediment samples will be collected and analyzed for particle size distribution.	WSRCD Fine sediment deposition on floodplains is critical for natural riparian regeneration. There may also be significant depositional differences between tributary generated flood events and dam generated flood events. Moderate priority	Anticipated CALFED Grant
Objective G5: Raise channel above bedrock hardpan, increasing alluvial storage within the bankfull channel. Hypothesis G5: Subsequent high flows and reductions in sediment supply upstream available upstream of the project will cause bankfull channel to begin incision.	Longitudinal thalweg surveys. Bedrock contacts along the proposed channel centerline will be surveyed as part of the design phase, as-built channel thalweg will be surveyed to document elevation above bedrock contacts, and subsequent surveys will track whether (and how much) incision occurs after specific high flow events that exceed bed mobility thresholds	Compare longitudinal profiles and cross sections prior to and after high flow events to determine patterns of aggregation and deposition.	WSRCD Without removing Saeltzer Dam and/or manually adding coarse sediment, reconstructed channel not controlled by bedrock will again begin to incise during high flow events large enough to transport coarse bed material. This monitoring will document where incision occurs and how much. Moderate priority	Anticipated CALFED Grant

II) Biological/Ecological Project Objectives for Geomorphology.				
OBJECTIVE/HYPOTHESIS	MONITORING PARAMETER (S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH	MONITORING AGENT, COMMENTS, STUDY PRIORITY	FUNDING
Objective G6: Recreate a properly sized alluvial channel morphology with adequate coarse sediment supply. Hypothesis G6: As the bankfull channel migrates, coarse and fine sediments will deposit on the inside of meander bend, creating a new functional floodplain.	The monitoring parameter will be bankfull channel width, bankfull channel depth, and perhaps estimates of bankfull channel boundary shear stress. These parameters will be obtained from cross sections installed throughout two alternate bar sequences (targeting meander bends.)	Evolution of cross section shape, dimensions, and perhaps boundary shear stress will be documented before and after discrete high flow events. Channel adjustment will also be considered in light of changing sediment loads, high flow magnitude, and high flow duration.	WSRCD Much of this will be collateral information gathered with other geomorphic monitoring activities. Channel dimension evolution will be used to improve future channel designs. Moderate priority.	Currently CVPIA, CALFED is anticipated future source.

Lower Clear Creek Floodway Rehabilitation Project
Riparian Revegetation Goals and Objectives Monitoring Table

OBJECTIVE/HYPOTHESIS	QUANTIFIED OBJECTIVES	MONITORING PARAMETER(S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH
Objective R1: Restore native woody riparian vegetation on newly created floodplain surfaces.	Attain a minimum survival rate of 50% of the plantings (defined as a planting space) after 3 growing seasons. Attain an average woody riparian planting height of 3 meters after 5 growing seasons. Produce an average woody riparian planting canopy cover of 20% in 5 years. Produce an average canopy cover of 100% in ten years on the floodplains for woody riparian plantings combined with native woody recruits.	Monitor the survival and productivity of the primary succession species for the first 5 years. Monitor survival and productivity of the secondary succession species for the next five years Monitor productivity of the primary succession species again at 10 years.	<u>Row Transects:</u> Establish and map fixed belt transects along randomly selected planting rows on the constructed floodplains. Monitor planting survival, canopy cover and height.
Objective R2: Create favorable physical conditions for regeneration of native woody riparian plant species on restored floodplains.	Produce an average canopy cover of 50% after 5 years in the scour channels of natural recruitment of native woody riparian plant species (**including non-native blackberry**). Produce an average canopy cover of 100% in ten years for woody riparian plantings combined with native woody recruits (**including non-native blackberry**) on the floodplains.	Monitor the number and canopy cover of woody plant species recruitment on the floodplains for 5 years. Monitor canopy again at 10 years. Monitor the canopy cover of woody plant species recruitment in the scour channels for 5 years. Monitor canopy again at 10 years.	<u>Row Transects:</u> Establish and map fixed belt transects along randomly selected planting rows on the constructed floodplains. Monitor number, height and canopy cover of woody recruited plants. <u>Scour Channel Transects:</u> Establish fixed linear transects at regular intervals along the scour channels. Monitor cover of woody recruited plants using a line-intercept method.

Lower Clear Creek Floodway Rehabilitation Project
Riparian Revegetation Goals and Objectives Monitoring Table

OBJECTIVE/HYPOTHESIS	QUANTIFIED OBJECTIVES	MONITORING PARAMETER(S) AND DATA COLLECTION APPROACH	DATA EVALUATION APPROACH
Objective R3: Restore native perennial herbaceous vegetation on newly created floodplain surfaces.	Attain a frequency ratio of 3:1 of native:non-native plants on the constructed floodplains after 10 years (5 years after herbaceous planting).	Monitor the frequency of native to non-native herbaceous plant species on the floodplains for 5 years following the initiation of an herbaceous planting program.	<u>Row Transects:</u> Establish fixed location quadrats along row transects on the constructed floodplains. Monitor frequency of herbaceous plant species occurrence.
Objective R4: Create favorable physical conditions for regeneration of native herbaceous plant species on restored floodplains.	Attain a frequency ratio of 3:1 of native:non-native plants in the scour channels after 5 years.	Monitor the frequency of native to non-native herbaceous plant species in the scour channels for 5 years. Monitor frequency again at 10 years.	<u>Scour Channel Transects:</u> Establish fixed location quadrats along scour channel transects. Monitor frequency of herbaceous plant species occurrence.
Objective R5: Reduce non-native species encroachment on rehabilitated floodplains	Eliminate colonies of target non native invasive weeds	Survey project footprint and surrounding areas for the presence of non native invasive weeds.	<u>Conduct Invasive Weed Surveys:</u> Complete weed surveys every three years and monitor established colonies
Objective R6; Create favorable conditions for the regeneration of native wetland species in areas to promote no loss of total wetland	Attain a replacement ratio of 1:1 for wetland losses as a result of floodplain restoration	Measure the total wetlands created through restoration of floodplains and channel rehabilitation	Delineation of waters of the U.S., including wetlands will be conducted in accordance with the 1987 *Corps of Engineers Wetlands Delineation Manual*

Biological/Ecological Project Objectives For Fisheries Monitoring

RESTORATION ACTION	GOAL	QUANTITATIVE OBJECTIVE	HYPOTHESES	PERFORMANCE MEASURE(S) & MONITORING METHOD	LINKS TO OTHER PROGRAMS
3a: Stream channel reconstruction (Lower Clear Creek Floodway Restoration Project) SCALE = 1-10 & 10-10^2 channel widths	**F5**:Improve the quantity and quality of salmonid spawning habitat. **F6**: Improve the quantity and quality of juvenile rearing habitat.	**F5-A**: Attain at least a 200% increase in spawning habitat use, over baseline period. **F5-B**: Attain egg survival-to-emergence (STE) equal to or greater than outside the project reach. **F6-A**: Channel features designed to provide juvenile habitat will be retained for >5 years and will be utilized at levels >100% above average densities in control reaches. **F6-B**: Attain average juvenile densities in the reconstructed channel that equal or exceed levels in control reaches.	**F5-A**: Channel reconstruction will increase spawning habitat use by Chinook. **F5-B**: Channel reconstruction will result in above average STE. **F6-A**: Channel features designed as rearing habitat will contain relatively high densities of juvenile Chinook. **F6-B**: Mean juvenile densities in the reconstructed channel	**F5-A**: Spawning habitat use (surface area of redds/redd aggregates) as measured by redd mapping (over a 10 year period). [TASK 2.2] **F5-A:** Weighted Usable Area as predicted by "River2D" hydraulic modeling. Use redd mapping to validate model. [TASK 9, 10] **F5-B**: STE rates for Chinook eggs hydraulicly placed in artificial redds and gravel quality parameters (e.g. temperature, bed scour, permeability, DO, Nitrogenous waste, and % fines). [TASK 6] **F6-A&B** : Density of juvenile Chinook as measure by direct observation (habitat use) surveys. [TASK 5] **F6-B**: Weighted Usable Area as predicted by "River2D" hydraulic modeling. [TASK 9, 10]	**F5-A**: EWP (Goal 2, Obj' a) **F5-B**: CCDAM (5.2.3) **F5-B:** EWP (Goal 2, Obj' e)

Biological/Ecological Project Objectives For Fisheries Monitoring

RESTORATION ACTION	GOAL	QUANTITATIVE OBJECTIVE	HYPOTHESES	PERFORMANCE MEASURE(S) & MONITORING METHOD	LINKS TO OTHER PROGRAMS
		F6-C: Attain aquatic macro-invertebrate prey densities in the reconstructed channel at 1) levels >100% above densities in clay hard-pan channel areas and 2) levels greater than densities in natural riffles.	will be greater than in control reaches. **F6-C**: Spawning gravel lining reconstructed channel reaches will increase the production & diversity of macro-invertebrate food sources for juvenile Chinook.	**F6-C**: Invertebrate production, density & diversity and ratio of predation susceptible to unsusceptible inverts. Measured by standard sampling methods. [TASK 7] **F6-C**: Analyze stomach contents of juvenile Chinook to confirm which invertebrates are prey species. [TASK 7]	**F6-C**: EWP (Goal 2, Obj' e) **F6-C**: CC AMF rpt

RESTORATION ACTION	GOAL	QUANTITATIVE OBJECTIVE	HYPOTHESES	PERFORMANCE MEASURE(S) & MONITORING METHOD	LINKS TO OTHER PROGRAMS
3b: Floodplain reconstruction (Lower Clear Creek Floodway Restoration Project)	**F6**: Improve the quantity and quality of juvenile rearing habitat.	**F6-A**: Designed floodplain scour channels will provide seasonal juvenile rearing habitat. **F6-B**: Determine which of 3 scour channel designs provides the most	**F6-A**: Scour channels, during the wet season, will provide suitable habitat for and be used by juvenile salmonids.	**F6-A&B**: Fish density, water temperature/depth/velocity, stranding/isolation (connectivity), presence of predators, duration and quantity of wetted area, and dissolved O_2 as measured during electrofishing & seining surveys. [TASK 12]	CVPIA CBDA CBDP milestone 59

Biological/Ecological Project Objectives For Fisheries Monitoring

RESTORATION ACTION	GOAL	QUANTITATIVE OBJECTIVE	HYPOTHESES	PERFORMANCE MEASURE(S) & MONITORING METHOD	LINKS TO OTHER PROGRAMS
SCALE = 1-10 & 10-10^2 channel widths		suitable habitat for juvenile salmonids based on fish density and environmental conditions.	**F6-B**: The 3 scour channel designs are not equally suitable for juvenile salmonids.		
	F7: Reduce juvenile salmonid stranding on floodplains.	**F7**: Reconstructed floodplains will reduce juvenile stranding to levels at or below levels found on nearby floodplains.	**F7**: Juvenile stranding rates on constructed floodplains will be lower than on nearby floodplains.	**F7**: Stranding rate (fish/m^2) as measured by floodplain stranding surveys. [TASK 11]	**F7**:CBDP milestone 71
	F8: Improve adult upstream passage conditions through the project reach.	**F8**: Eliminate stranding and passage hindrances for adult Chinook in the project reach.	**F8**: Filling of gravel mining pits in the floodplain will eliminate passage problems for adult salmon through the project reach.	**F8**: Objective met. No stranding or passage problems remain. No monitoring needed.	**F8**:CBDP milestone 67